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PACKAGING ELECTRONIC CIRCUITRY INSIDE FERRITE POT CORES

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PACKAGING ELECTRONIC CIRCUITRY

INSIDE FERRITE POT CORES

THE CONCEPT AND ADVANTAGES

The ferrite pot core can offer several advantages by means of its special construction which haven't been previously exploited. With special attention to materials, component placement, and minimizing interaction of components inside a strong B-field, it is certainly within the scope of present technology to package the electronic circuitry within a specially enlarged pot core which presently houses only the wire-bobbin. Thin-film, thick film, integrated circuitry, and their hybrid-combinations offer many possibilities for reducing the circuitry size to meet this objective.

The advantages to be considered are:

1. This packaging technique affords a logical vehicle for utilizing the latest microcircuit techniques for size reduction. The pot core offers a compact, durable, and machinable structure which can be reliably mounted to any material. It also exhibits an inherent heat sink capability through the ferrite material and in addition by means of the aluminum stud through the center of the core. This stud clamps the two parts together and mounts the core onto a retaining structure.

2. It offers small, compact, modular circuits which can be used as building blocks for larger systems. The ferrite material not only shields its internal circuitry from external RFI, but is much more effective in reducing internally generated electromagnetic radiation than the toroid core construction. The modular concept is also evidenced because only input-output type connections are required. In the special case of high voltage generation, the high tension output can be brought out separately and completely isolated from other leads, simply, reliably, and usually directly from the point in the circuitry where it is generated, thereby minimizing or even eliminating the necessity of running high potential wires point-to-point within or outside of the module.

3. When placed in a nuclear radiation flux field, a modular circuit packaged inside of the ferrite pot core has obvious built-in

protection. Not only is the least affected part of the circuitry, the magnetic material, placed directly into the incident radiation, but this same material will be an excellent nuclear radiation shield from high energy proton, electron, and gamma radiation. Also by design the interior microcircuitry would have to be considered radiation-resistant because of their relatively small size and high frequency operation necessitated by the pot core size constraint.

HIGH VOLTAGE CONVERTER PACKAGED WITHIN POT CORE

Perhaps the best way to illustrate the technique would be to consider how an actual circuit can be packaged inside of the pot core. Figure 1 shows the cross-section of a pot core specially constructed to house a low voltage pre-regulator, an oscillator, and capacitor-diode voltage multiplier chain. In this case the pot core has an interior air gap because of the oscillator design. Two holes will be drilled into the

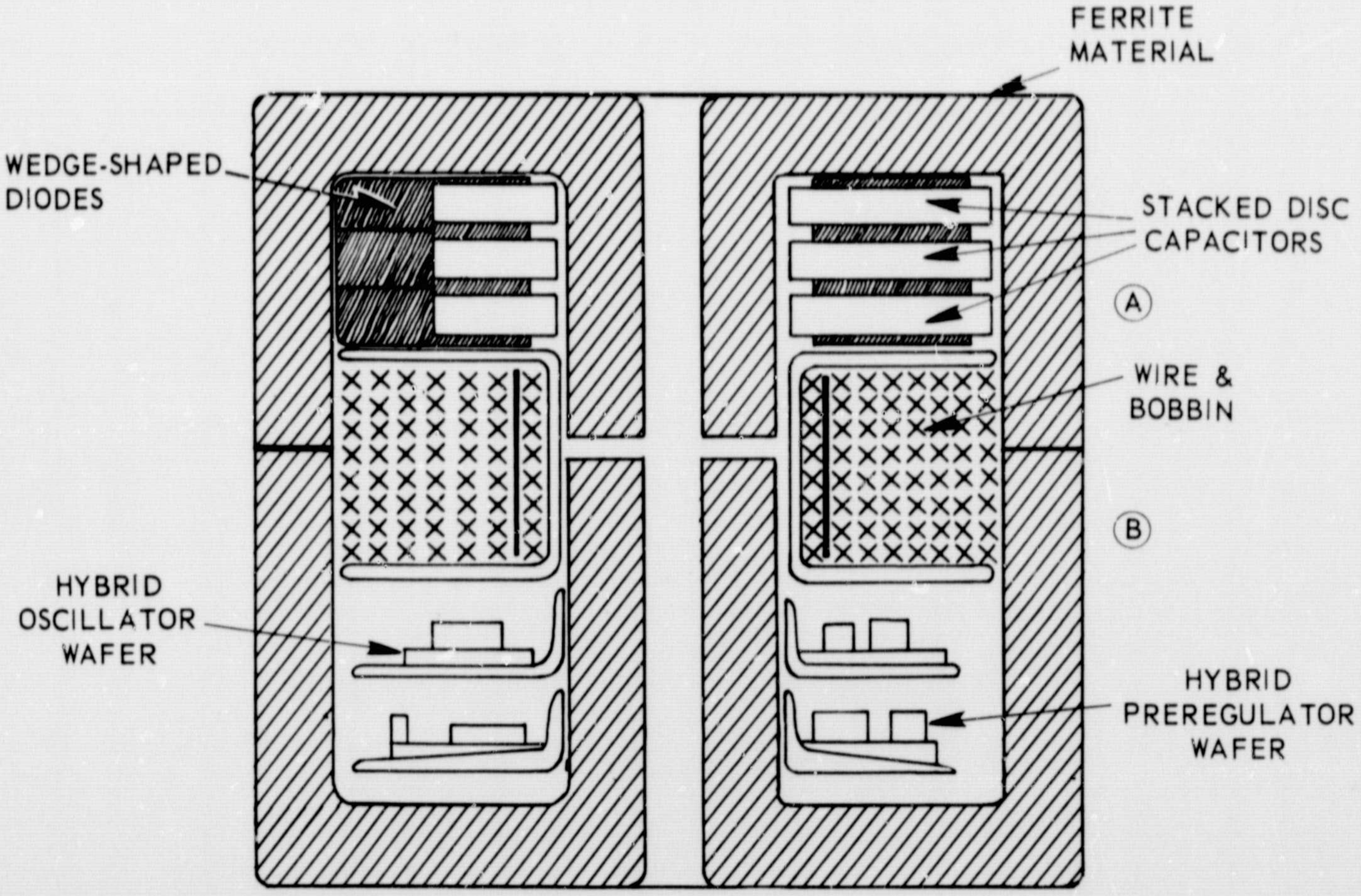

Figure 1.

pot core, one on the bottom of the pot core to bring in the low voltage input power, and the second at the top of the core to bring out the high-potential output.

Figure 2 shows an exploded view of the capacitor-diode voltage multiplier chain. Note the gap in each electrode to prevent a shorted turn within the B-field. Capacitors would be normal high voltage disc

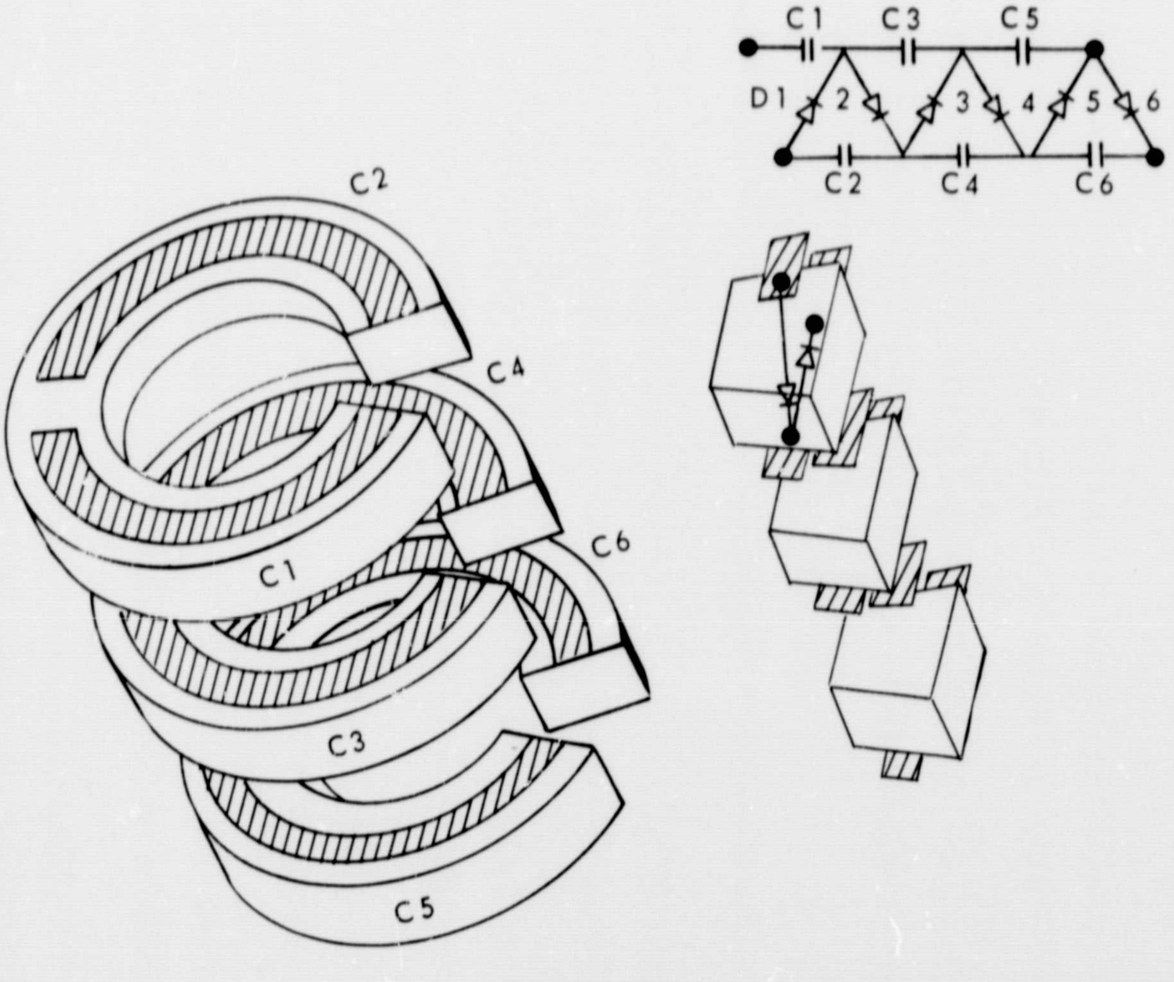

Figure 2.

type with centers drilled out and specially masked electrodes. The diodes could either be specially encapsulated in the wedge shape depicted in Figure 2 or individual diodes soldered point-to-point. There are many available types of high voltage, low current diodes with lengths down to .085". Stacking the capacitor electrodes back-to-back with a slot in one perimeter for diode placement will utilize the maximum volume in the core for the high voltage step-up and allow simple positive contact to be made with really no interconnecting wires. Instead small beads of solder could be formed on each electrode and when the electrode is heated this bond would "wet" each electrode surface for positive bonding.

The wire bobbin could be placed in the vicinity of the air gap (precision ground in the center of the pot core). Since this is the region where leakage flux is the highest, the effects upon the associated electronic package will be minimized, and the performance of this leakage on the wire bobbin is readily accountable.

The hybrid circuits necessary to provide the oscillator and preregulator could be placed on separate washer-shaped wafers. Thick film cermet techniques could provide the passive circuitry and discrete semiconductor elements (each previously screened for flight) could be added either as flip-chips or small chips bonded to the cermet substrate.

In order to provide uniformity and to utilize as many of the same parts as possible, only one or two pot core diameters should be chosen. This would mean that perhaps the top half of the pot core could be the manufacturer's normal production-run and commercially available; thus precision ground air gaps available commercially are also inherent if the pot core side with this gap is ordered. The bottom half of the pot core could be provided in several depths to accommodate various amounts of components for higher voltage output; various frequencies of operation; differing power levels; and the degree of complexity of the interior electronics package.

By limiting the interior diameter, hybrid circuit wafers, wire bobbins, and capacitor sizes are necessarily limited. Therefore only one or two types of capacitor values at one voltage rating need be supplied and higher or lower output voltage would be provided by adding or removing capacitor/diode stacks. The ripple requirement could be met by changing the oscillator frequency which may alter the height of the wire bobbin. Input voltage changes could be accomplished in the preregulator wafer and power levels could be handled by trimming passive components on the thick film surface and/or changing discrete semiconductor elements. Also external means are still available for "trimming" high voltage outputs, by trimming an external resistor.

TESTING THE PACKAGE IN A NUCLEAR RADIATION FIELD

To ascertain the degree of shielding provided by this packaging scheme it would be necessary to test a package in a nuclear environment dictated by the requirements of the spacecraft mission. As a control all of the normally interior, shielded electronics would be mounted on a board exterior to the pot core. Also a similar circuit inside the core would be mounted in close proximity to the control so that each circuit would receive the same effective radiation exposure. Each circuit would be operated until failure or until the mission time schedule is complete.

SUMMARY

Electronic circuits which utilize magnetic core material for their operation can be packaged inside of this material in many instances. There are many advantages to this technique in reducing the size; simplifying to modular packaging; inherent radiation and electromagnetic shielding; simple, functional, three-dimensional layout; and a self supporting package with good thermal transfer capabilities. Since ferrite material is recommended in the form of a moulded pot core, a high frequency design constraint may be imposed on the designer, but again for spacecraft circuitry this may be considered a bonus.